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Multivariate analysis of morphometric characters in the Eastern hedgehog *Erinaceus concolor* from Greece and adjacent areas

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Abstract

A number of subspecies of the eastern hedgehog *Erinaceus concolor* has been described in the southern Balkan peninsula. Despite extensive morphological and karyological descriptions, their taxonomic status is still unclear. In the present study we have attempted to identify this status in different populations from mainland and insular Greece and to clarify their relationships to subspecies from adjacent areas. Multivariate analysis of 21 somatic and cranial characters was performed on 191 specimens from Greece, and also on published data (76 from Bulgaria, 21 from Yugoslavia and 9 from Asia Minor).

Our analysis showed that throughout the mainland of the southern Balkan peninsula, one large-sized subspecies, *E. c. bolkayi*, is distributed. Two insular subspecies of smaller body size are found on the Greek islands: *E. c. nesiotes* on Crete, Kyklades islands and Ionian sea islands and *E. c. rhodius* in the eastern Aegean sea islands Rhodos, Samos, and Chios. The subspecies *E. c. transcaucasicus* also appears to occur on the islands of Lesvos and Kos.

Introduction

The eastern hedgehog *Erinaceus concolor* has an extensive distribution in eastern Europe and west Asia: Poland, Czech Republic, Slovakia, Austria, north-eastern Italy, Balkan peninsula, Turkey, southern Russia, west side of the Caspian Sea and western Siberia as well as in Israel, northern Iraq and northern Iran (Corbet 1988; Holz and Niethammer 1990). In this vast area, the hedgehog displays such a degree of variation, particularly in colour and size, that a considerable number of subspecies has been described. A melanic form *Erinaceus concolor concolor* (or *E. c. ponticus*) is distributed on the eastern shore of the Black Sea and a pale form *E. c. palidus* in west Siberia (Ognev 1928; Corbet 1988).

Using a multivariate analysis of skull measurements, Holz (1978) showed that apart from the western and eastern hedgehog, a third type exists in south-eastern Europe (Romania-Bulgaria) with a smaller cranial capacity and a longer cranium. It is not certain whether this type belongs to the species *E. concolor*, to the subspecies *E. c. transcaucasicus* (Satunin, 1905), or to a third species not yet described.

Kratochvil (1980) states that the hedgehogs inhabiting lowland steppes of the Balkan peninsula have a smaller mean capacity of the skull cavity and belong to the form described as *E. c. drozdovskii* (Martino 1933). Thus, according to Kratochvil (1980) the European continent is populated by two separate subspecies of *Erinaceus concolor* differing in somatic and craniological characters i. e. *roumanicus* and *drozdovskii*. The form *drozdovskii* has been described as a "morpha" of the subspecies *Erinaceus roumanicus*

bolkayi (MARTINO 1930), being lighter in colour and larger in size and distributed in the mountaneous regions of Montenegro, Yugoslavia (MARTINO 1933; PETROV 1940). Some authors considered *bolkayi* and *drozdovskii* two separate subspecies of the eastern hedgehog, larger in body size than the subspecies *E. c. roumanicus* (MARKOV 1957; MARKOV and DOBRIJANOV 1974; MALEC and STORCH 1963; ĐULIC and MURIC 1967; ONDRIAS 1966). According to WETTSTEIN (1966) the hedgehogs from Asia Minor belong to *E. c. transcaucasicus* (Satunin, 1905). He considered it as a subspecies synonymous with *drozdovskii*, which belongs to Anatolian populations. This subspecies has also been found on Kos (DE BEAUX 1929).

Fig. 1. Distribution map of the subspecies of *Erinaceus concolor* in Greece. • = *E. c. bolkayi*, ▲ = *E. c. nesiotes*, ■ = *E. c. rhodius*, * = *E. c. transcaucasicus*. Continental Greece: a = Attica (a_1 = Koropi, a_2 = Parnitha), b = Boiotia (Thebes), e = Evoia (e_1 = Aliveri, e_2 = Edipsos), l = Fthiotida (Lamia), f = Fokida (f_1 = Lidoriki, f_2 = Tichio), g = Aetoloakarnania (Agrinio), i = Epiros (Ioannina), s = Thessalia (s_1 = Karditsa, s_2 = Trikala, s_3 = Kalambaka, s_4 = Elassona), m = Makedonia (m_1 = Florina, m_2 = Alexandria, m_3 = Kilkis, m_4 = Serrae), t = Thrace (t_1 = Alexandroupolis, t_2 = Soufli). Peloponnisos: 1 = Kastritsi (Patra), 2 = Pyrgos, 3 = Kiparissia, 4 = Astros (Kinouria), 5 = Korinthos. Crete: 1 = Chania, 2 = Rethymno, 3 = Iraklio, 4 = Agios Nikolaos, 5 = Ierapetra.

An extensive karyological investigation of hedgehogs in Greece has shown that three subspecies of the eastern hedgehog *E. concolor* are distributed throughout the country (Giagia and Ondrias 1980). The large-sized hedgehog of the Balkan peninsula was first described in the mainland as *E. c. drozdovskii*. However, a recent morphological study showed that it should be denominated *E. c. bolkayi* (Giagia and Ondrias 1995). An insular subspecies, *E. c. nesiotes* (Bate, 1905), is found on the island of Crete and is karyotypically identical to the mainland form, while a second insular subspecies *E. c. rhodius* (Festa, 1925) is found on the island of Rhodos and differs karyotypically from the other two subspecies (Giagia and Ondrias 1980). Some hedgehogs from the island of Vis in Yugoslavia have been described under the name *E. c. nesiotes* (Đulic and Tvrtkovic 1979).

In the present study, we attempted to give a global view of the morphometric relationships among the populations of *E. concolor* throughout Greece and to clarify their relationships with the neighbouring subspecies that have been previously described.

Material and methods

The present analysis was performed on 191 specimens constituting eleven populations collected from the mainland of Greece and its numerous islands (Fig. 1). Only adults were used to minimize the effect

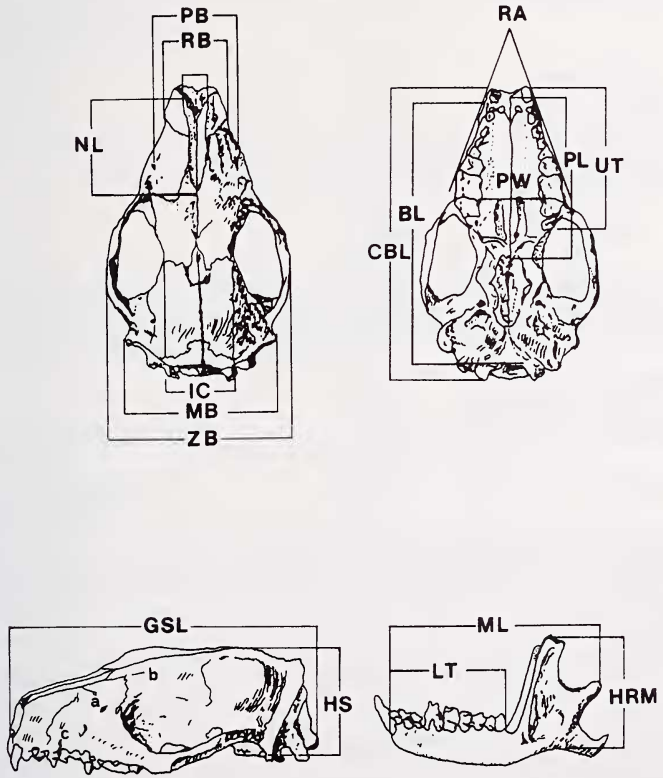

Fig. 2. Measurements taken on skulls of *Erinaceus concolor* (GSL = greatest skull length, CBL = condylobasal length, BL = basal length, ZB = zygomatic breadth, MB = mastoid breadth, IC = interorbital constriction, NL = nasal length, RB = rostrum breadth, PB = postorbital breadth, PW = palate width, UT = upper toothrow, ML = mandible length, LT = lower toothrow, HS = height of skull, PL = palate length, HRM = height of ramus mandibulae, RA = rostral angle).

of allometric variation associated with growth. Twentyone measurements, four bodily (HB = head and body length, TL = tail length, EL = ear length, and HFL = hind foot length) and seventeen cranial measurements (Fig. 2), were selected for the present analysis. In addition, two indices that have been used for the study of the hedgehog (Wettstein 1942; 1966; Ruprecht 1972) were calculated: maxillary index (Mi = a – b/a – c) and length index (Li = CBL/ZB).

Additional data from Bulgaria (Markov 1957), Yugoslavia (Đulic and Tvrtkovic 1979; Martino 1933; Petrov 1940) and Asia Minor (Wettstein 1966) were used for comparative purposes.

A list of all populations including the measurements used is given in table 1. Cranial measurements were taken as defined by Hrabe (1976) with a precision of 0.1 mm or 0.5 degree in the case of the rostral angle (Ruprecht 1972).

Data were subjected to canonical (discriminant) analysis (CA) and principal components analysis (PCA) after their logarithmic transformation. MANOVA was used to detect differences between populations (Morrison 1976; Reyment et al. 1984) and Mahalanobis distances between population centroids in order to construct a UPGMA phenogram (Sneath and Sokal 1973). The statistical packages SYSTAT (Wilkinson 1987) and NT-SYS (Rohlf 1992) were used throughout this study.

Table 1. Populations, sample sizes and variables (in common) studied.

No	Description	Code	Sample size	Variables used
1	Continental Greece	CG	49	HB, TL, HFL, EL, GSL, CBL, BL, ZB, MB, IC, NL, RB, PB, PW, UT, ML, LT, HS, PL, HRM, RA
2	Peloponnisos	PE	76	”
3	Crete (*E. c. nesiotes*)	CR	15	”
4	Rhodos (*E. c. rhodius*)	RH	9	”
5	Lesvos	LE	12	”
6	Kyklades islands	KY	4	”
7	Kerkyra	KE	5	”
8	Kephalonia	KP	3	”
9	Kos	KO	5	”
10	Samos	SA	7	”
11	Chios	CH	6	”
12	Bulgaria (*E. c. drozdovskii*)	Bd	23	HB, TL, HFL, EL, GSL, CBL, ZB, MB, IC, NL, RB, PB, UT, ML, LT
13	Bulgaris (*E. c. bolkayi*)	Bb	23	”
14	Bulgaria (*E. c. roumanicus*)	Br	30	”
15	Yugoslavia (*E. c. drozdovskii*)	Yd	6	HB, TL, HFL, EL, CBL, ZB, UT, ML, LT
16	Yugoslavia (*E. c. bolkayi*)	Yb	6	HB, TL, HFL, EL, CBL, ZB, MB, NL, RB, UT, ML, LT
17	Yugoslavia (*E. c. nesiotes*)	Yn	9	”
18	Asia Minor (*E. c. transcaucasicus*)	Tt	9	CBL, ZB

Results

Preliminary analysis

A preliminary analysis included the pooling of sexes and the pooling of specimens from all mainland Greek localities. Sexual dimorphism was tested in the largest sample from Peloponnisos (34 males and 49 females) and was not significant (MANOVA, $p > 0.05$).

As the number of specimens collected from different localities of the mainland is rather low, they were pooled and tested by the inspection of the principal component plots (the first two, accounting for 53% of the total variability, are shown in Fig. 3). No

pattern of variation was found among the specimens from these localities. Similar results were obtained for other component plots (not shown). Thus, the pooled specimens from the Greek mainland will be referred to as the Continental Greek population. (CG in Tab. 1).

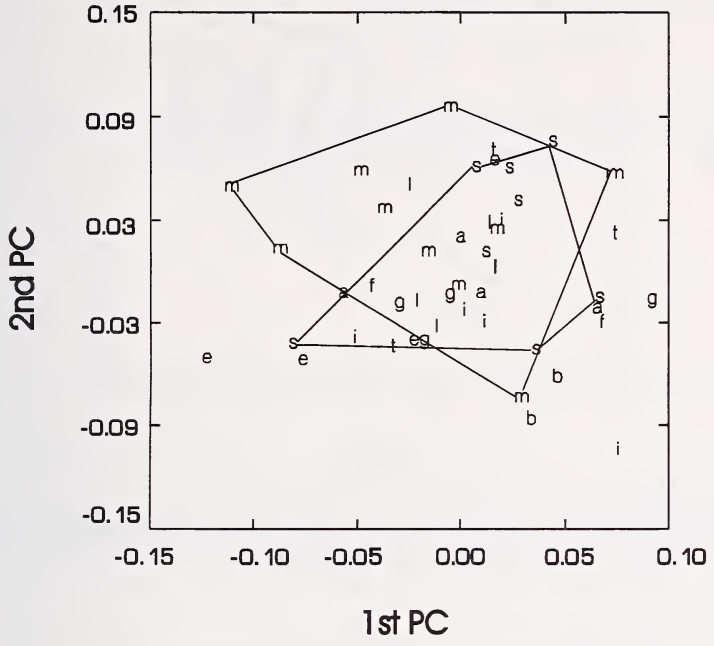

Fig. 3. First and second principal component (PC) plot of the continental Greek population (CG). Borders of the largest subpopulations (Macedonia and Thessalia) are also plotted for comparative purposes. Abbreviations as in figure 1.

Canonical analysis (CA)

CA of Greek populations

From the eleven Greek populations studied (Tab. 1) the first five were considered as main populations because their samples comprise a sufficient number of individuals and represent the known subspecies of *Erinaceus concolor* distributed in Greece (except for those from the island of Lesvos). The six further populations that come from differenf islands of Greece all contain a small number of specimens and one cannot be certain to which subspecies they belong. The main Greek populations were subjected to CA. MANOVA was significant (Wilk's $\Lambda = 0.0352$, $F = 8.44$, $p < 0.0001$) as well as all pairwise contrasts between them ($p < 0.0001$). Canonical scores are plotted in figure 4. It is clear that the first canonical variate (CV) discriminates the insular from the mainland populations while the second one discriminates the Cretan population (*E. c. nesiotes*) from that of Rhodos (*E. c. rhodius*). The population from Lesvos of an uncertain taxonomic status, lies inbetween of all (Fig. 4). From the canonical coefficients in table 2 it can be concluded that CBL, ZB, BL, PL, and RA (1st CV) are the measurements playing an important role in the discrimination of mainland from insular populations, while UT, LT, CBL, GSL and PB are those that mostly discriminate Rhodos and Cretan populations (2nd CV).

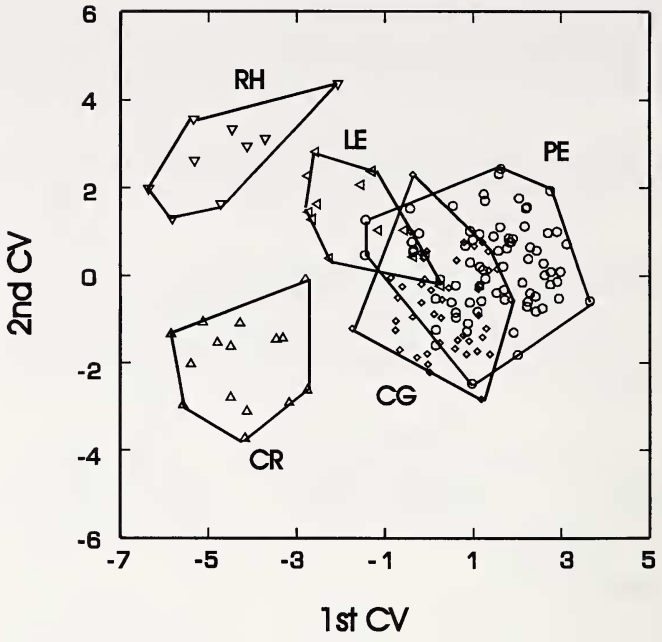

Fig. 4. First and second canonical variate (CV) plot of the five main Greek populations (nos. 1–5). Abbreviations as in table 1.

Table 2. Standardized canonical coefficients for canonical analysis of the five main Greek populations (1–5). First CV accounts for 65.6% and second for 17.3% of the total between group variability.

	1st CV	2nd CV	3rd CV.	4th CV.
HB	–0.046	–0.153	–0.306	0.352
TL	0.145	0.440	0.321	0.034
EL	0.022	–0.112	0.102	–0.192
HFL	–0.082	0.063	–0.314	–0.261
GSL	0.223	0.540	–0.664	–0.050
CBL	–0.877	–0.630	0.352	0.615
BL	0.554	–0.344	–0.056	0.180
ZB	0.617	–0.161	0.470	–0.349
MB	–0.388	0.378	0.618	–0.054
IC	–0.246	–0.096	–0.139	–0.215
NL	0.279	–0.019	0.334	–0.160
RB	0.073	0.206	0.778	0.017
PB	0.039	–0.504	–0.333	0.136
PW	–0.018	–0.025	0.347	0.075
UT	–0.378	1.243	–0.348	–0.113
ML	–0.028	0.179	–0.818	–1.221
LT	0.069	–0.533	–0.177	1.144
HS	0.025	–0.042	–0.306	–0.468
PL	–0.500	–0.397	0.529	0.455
HRM	–0.165	–0.442	–0.119	–0.065
RA	–0.459	–0.073	–0.276	0.111

The insular populations (no. 6–11 in Tab. 1) were subsequently classified into the main classes and the results are shown in table 3. It is clear that the population from Kyclades (KY as well as those from the Ionian islands, i. e. Kephalonia (KP) and Kerkyra (KE), are all classified into the Cretan (CR) population. The population from Samos (SA) is mostly classified in the population from Rhodos (RH). The populations from Chios (CH) and Kos (KO) have uncertain positions. Note that the specimens from Kos are karyologically closely related to Rhodos population (MANDAHL 1978).

Table 3. Subsequent classification of the small Greek insular populations (6–11) into the main categories (1–5). Abbreviations as in table 1. This classification was based on the Mahalanobis distances from each specimen to the centroids of the main populations.

	CR	PE	CR	RH	LE
KY	–	–	4	–	–
KE	–	–	5	–	–
KP	–	–	3	–	–
KO	2	–	2	–	1
SA	–	–	–	5	2
CH	1	–	2	2	1

CA of the Bulgarian populations

Canonical variate plot of the three Bulgarian subspecies (Fig. 5) described by MARKOV (1957) reveals that *E. c. roumanicus* and *E. c. drozdovskii* are clearly different subspecies (MANOVA, $p < 0.0001$), while *E. c. bolkayi* is an intermediate form significantly different from *E. c. roumanicus* ($p = 0.005$) but not from *E. c. drozdovskii* ($p = 0.022$).

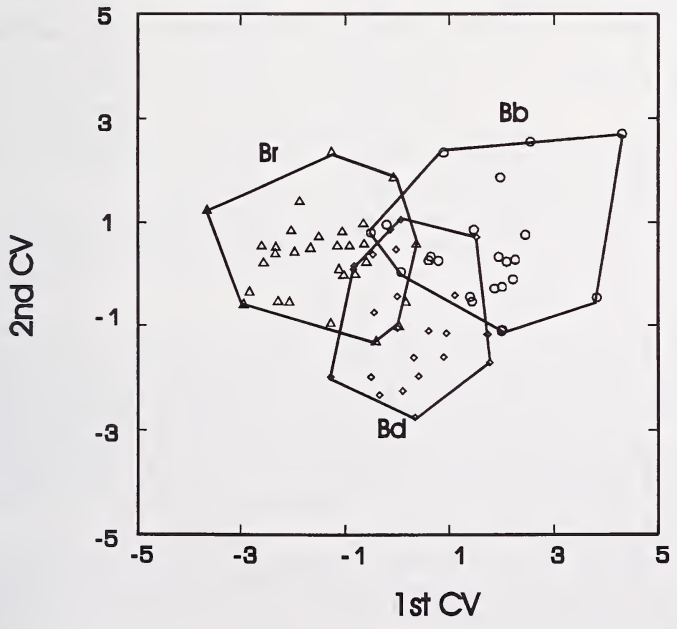

Fig. 5. First and second canonical variate (CV) plot of the three Bulgarian populations (nos. 12–14). Abbreviations as in table 1.

CA of Greek and Bulgarian populations

Using the 15 measurements (common to all Greek and Bulgarian material, see Tab. 1) an 8-group CA including both main Greek and Bulgarian populations was made. The UPGMA tree (Fig. 6) based on Mahalanobis distances revealed that the Greek mainland populations (CG and PE) are different from all the Bulgarian populations (MANOVA, $p < 0.001$). Insular Greek populations clearly form another cluster, with the exception of the island of Lesvos which is closer to the continental Greek populations.

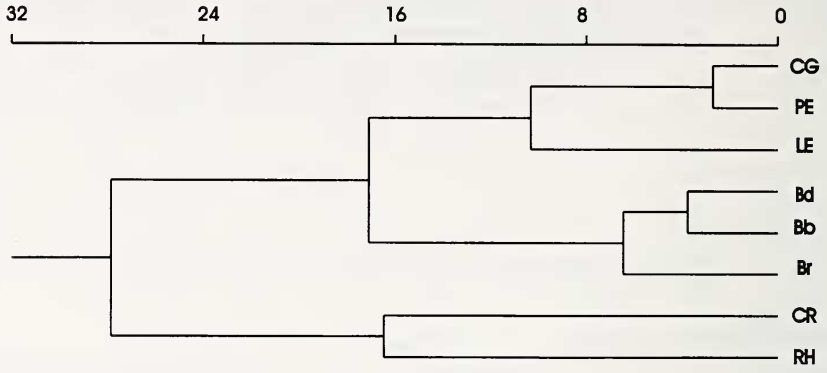

Fig. 6. UPGMA phenogram of the five main Greek (nos. 1–5) and the three Bulgarian (nos. 12–14) populations, based on the Mahalanobis distances between centroids. Abbreviations as in table 1.

Comparison of neighbouring populations from southern Balkan Peninsula and Asia Minor

The Yugoslavian population of hedgehogs from Vis island, described as *E. c. nesiotes* (Đulic and Tvrtkovic 1979), was compared to the Greek insular populations from the islands of Crete, Rhodos and Lesvos. The Mahalanobis distances calculated confirm that the Yugoslavian population is closer to the Cretan form than to the other Greek insular populations, but remains significantly different from it ($p < 0.001$).

The specimens from the Ionian islands, Kerkyra and Kephalonia, were pooled in one population and compared to Yugoslavian insular population from Vis, because these islands are geographically closer to Vis than any other Greek island. We found a significant difference between them ($p < 0.001$).

The mainland Yugoslavian populations, representing *E. c. bolkayi* (Đulic and Tvrtkovic 1979) and *E. c. drozdovskii* (Martino 1933; Petrov 1940), due to the small size of samples cannot be analysed with confidence. The Mahalanobis distances between centroids indicated that: a) Yugoslavian *bolkayi* is closer to Bulgarian *drozdovskii* than to its Bulgarian counterpart. b) Yugoslavian *drozdovskii* is closer to its Bulgarian counterpart than to any other population. c) Yugoslavian *bolkayi* is very close to the Greek mainland populations from continental Greece and Peloponnisos d) Yugoslavian *drozdovskii* and Yugoslavian *bolkayi* are very closely related.

Finally, the specimens from Asia Minor, described as *E. c. transcaucasicus* by Wettstein (1966), were compared to all other populations. With only two measurements available (CBL and ZB), they were found to be different from all populations, except those from Lesvos (MANOVA, $p = 0.20$).

Indices

The basic statistics for Mi and Li in all populations are given in table 4. Length index is generally constant among the studied populations of *Erinaceus concolor*, except those from the islands of Rhodos and Samos which differ significantly from the others (ANOVA, $p < 0.001$).

Maxillary index varies amongst the five main Greek populations and the insular Yugoslavian population (no. 1–5 and no. 17 in Tab. 1) while the ANOVA (Tukey's test), groups together the populations from continental Greece, Peloponnisos, Crete and Vis island, on one hand, and the populations from Rhodos and Lesvos, on the other. These results are in accordance with our karyological data which differentiate the specimens of the Greek mainland and Crete from those of the islands of Rhodos and Lesvos (Giagia and Ondrias 1980).

Table 4. Basic statistics (means and standard deviations = sd) of the two indices in the 18 populations studied.

Population	Length index		Maxil. index	
	mean	sd	mean	sd
CG	1.66	0.05	1.07	0.14
PE	1.69	0.05	1.14	0.11
CR	1.67	0.05	1.15	0.10
RH	1.56	0.05	0.77	0.09
LE	1.64	0.04	0.92	0.05
KY	1.69	0.05	1.10	0.18
KE	1.64	0.04	0.94	0.04
KP	1.63	0.02	0.88	0.07
KO	1.63	0.02	0.95	0.16
SA	1.58	0.04	0.88	0.05
CH	1.61	0.06	0.74	0.13
Bd	1.68	0.09		
Bb	1.66	0.05		
Br	1.66	0.07		
Yd	1.66	0.05	1.21	0.21
Yb	1.62	0.07		
Yn	1.62	0.04	1.18	0.11
Tt	1.61	0.05		

Discussion

The results of the above morphometric analysis of the Greek populations support the previously expressed view that one large-sized subspecies of eastern hedgehog is distributed throughout mainland Greece (Giagia and Ondrias 1995).

The analysis of Bulgarian hedgehogs, based on data given by Markov (1957), showed that two distinct subspecies occur throughout the country; the small-sized *E. c. roumanicus* and one large-sized subspecies including *bolkayi* and *drozdovskii*, which were previously described as being different.

The comparison of the neighbouring populations from Yugoslavia, Bulgaria and Greece showed that previously there was confusion concerning the name of the large-sized hedgehog described by Martino (1930, 1933) and reported by Holz (1978) and Kratochvil (1980) as occurring in the southern Balkan peninsula (Malec and Storch 1963; Petrov 1940; Wettstein 1942).

Although the populations from the mainland of Greece and Bulgaria are quite clearly different, they do overlap to some extent and are characterized by morphometric continuity. It is suggested that one large-sized subspecies *E. c. bolkayi* is distributed throughout the southern Balkan peninsula.

The CA of the Greek insular populations showed that two small-sized subspecies are distributed throughout Greek islands. *E. c. nesiotes* (Bate, 1905) from Crete appears to occur also on other islands of the Aegean sea such as Syros, Tinos, Naxos in the Kyclades, as well as on the Ionian sea islands, Kerkyra and Kephalonia. According to Đulic and Tvrtkovic (1979) the distribution of *E. c. nesiotes* extends up the Adriatic sea to the island of Vis. The analysis showed that the Yugoslavian insular population is rather different and must be reexamined. The subspecies *E. c. rhodius* (Festa, 1929) from the island of Rhodos is also distributed on Samos and probably Chios, as the karyological data confirm (Giagia and Ondrias 1980). The hedgehogs from the island of Kos although karyologically identical to those from Rhodos (Mandahl 1978) hold an uncertain position. De Beaux (1929) described some hedgehogs from the island of Kos as belonging to *E. c. transcaucasicus* which is found in Asia Minor.

Finally, the position of hedgehogs from Lesvos island in CA and their similarity to the specimens from Asia Minor, support the view that *E. c. transcaucasicus* is probably distributed on Lesvos, although the set of measurements is not sufficient to draw definite conclusions. This may be supported by the fact that many species distributed in Asia Minor are also found amongst Lesvos fauna (Giagia et al. 1982; Ondrias 1966). An extensive study of hedgehogs from Asia Minor as well as the study of more specimens from the East Aegean sea islands might clarify the relationships among the insular populations (*E. c. rhodius*) and those from Asia Minor (*E. c. transcaucasicus*).

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Zusammenfassung

Multivariate Analyse morphometrischer Merkmale beim Ostigel Erinaceus concolor in Griechenland und benachbarten Gebieten

Von der südlichen Balkanhalbinsel sind eine Reihe von Unterarten des Ostigels *Erinaceus concolor* beschrieben worden. Trotz umfangreicher morphologischer und karyologischer Beschreibungen ist ihr taxonomischer Status immer noch unklar. In der vorliegenden Studie wird versucht, den Status der verschiedenen griechischen Festland- und Inselpopulationen zu identifizieren und ihre Beziehungen zu Subspezies in Nachbarregionen zu klären. Dazu wurde eine multivariate Analyse von 21 somatischen und kranialen Merkmalen an 191 griechischen Exemplaren sowie anhand veröffentlichter Daten (76 aus Bulgarien, 21 aus Jugoslawien und 9 von Kleinasien) durchgeführt.

Die Analyse zeigt, daß auf dem gesamten Festland der südlichen Balkanhalbinsel die großwüchsige Subspezies *E. c. bolkayi* verbreitet ist. Zwei Insel-Unterarten mit geringerer Körpergröße kommen auf griechischen Inseln vor: *E. c. nesiotes* auf Kreta, den Kykladen und den Ionischen Inseln, *E. c. rhodius* auf den ostägäischen Inseln Rhodos, Samos und Chios. Die Subspezies *E. c. transaucasicus* kommt auf den Inseln Lesbos und Kos vor.

References

Corbet, G. B. (1988): The family Erinaceidae: a synthesis of its taxonomy, phylogeny, ecology and zoogeography. Mammal Rev. **18**, 117–172.

De Beaux, O. (1929): Richersche faunistice nelle isole Italiane dell Egeo, Mammiferi. Arch. Zool. Ital. Napoli **13**, 5–24.

Đulic, B.; Muric, D. (1967): Catalogus Fannae Jugoslaviae. **IV/4** Mammalia. Ljubljana: Cons. Acad. Sci., R.S.F.J.

Dulic, B.; Tvrtkovic, N. (1979): On some mammals from the central Adriatic and south Adriatic islands. Acta Biol. (Zagreb) **43**, 15–35.

Giagia, E. B.; Ondrias, J. C. (1980): Karyological analysis of eastern hedgehog *Erinaceus concolor* in Greece. Mammalia **44**, 59–72.

Giagia, E. B.; Savic, I.; Soldatovic, B. (1982): Chromosomal analysis of the mole rat *Microspalax* from Greece and Turkey. Z. Säugetierkunde **47**, 231–236.

Giagia-Athanasopoulou, E. B.; Ondrias, I. C. (1995): The Distribution of the Eastern Hedgehog *Erinaceus concolor bolkayi* in continental Greece. Säugetierkundl. Mitt. **36**, 153–173.

Holz, H. (1978): Studien an europäischen Igeln. Z. zool. Syst. Evolut.-forsch. **16**, 148–165.

Holz, H.; Niethammer, J. (1990): *Erinaceus concolor* Martin, 1838 – Weißbrustigel, Ostigel. In: Handbuch der Säugetiere Europas. Hrsg. von J. Niethammer and F. Krapp. Wiesbaden: Aula Verlag. Vol. **3/I**, 50–64.

Hrabe, V. (1976): Variation in cranial measurements of *Erinaceus concolor roumanicus* (Insectivora, Mammalia). Zool. Listy **25**, 303–314.

Kratochvil, J. (1980): Hirnmasse der mitteleuropäischen Arten der Gattung *Erinaceus* (Insectivora, Mamm.). Folia Zoologica **29**, 1–20.

Malec, F.; Storch, G. (1963): Kleinsäuger (Mammalia) aus Makedonien, Jugoslavien. Senck. Biol. **44**, 155–173.

Mandahl, N. (1978): Variation in c-strained chromosome regions in European hedgehog. Hereditas **89**, 107–128.

Markov, G. (1957): Die Insekten fressenden Säugetiere in Bulgarien. Sofia: Zool. Inst. Bulgar. Acad. Wiss. Sofia. Fauna Bulgariens III.

Markov, G.; Dobrijanov, D. (1974): Karyologische Analyse der Weißbrust- oder Ostigel (*Erinaceus roumanicus* Barr.-Ham.). in Bulgarien. Zool. Anz. **193**, 181–188.

Martino, V. E. (1930): Notes on the ecology of some mammals from Yugoslavia. Zap. Russ. Naush. Inst. Belgrade **2**, 53–65.

Martino, V. E. (1933): Novi jer iz vardarske bavonine. Prirod Razpr. Ljubljana **2**, 56–57.

Morrison, D. F. (1976): Multivariate statistical methods. (2nd ed.). New York: Mc Graw-Hill.

Ognev, S. I. (1928): Mammals of Eastern Europe and Northern Asia. Vol. 1 Insectivora and Chiroptera. Moscow. (English translation 1962, Jerusalem: Israel Programme of Scientific Translations).

Ondrias, J. C. (1966). The taxonomy and geographical distribution of the rodents of Greece. Säugetierkundl. Mitt. **14**, 1–136.

Petrov, B. M. (1940): Bemerkungen über die Systematik und Ökologie der Säugetiere Süd-Serbiens. d. h. Mazedoniens. Zap. Russ. Naush. Inst. Belgrade **16**, 57–64.

Reyment, R. A.; Blackith, R. E.; Campbell, N. A. (1984): Multivariate morphometrics. (2nd ed.). London: Academic Press.

Rohlf, F. J. (1992): NT-SYS. Numerical Taxonomy System. Exeter: Software.

Ruprecht, A. L. (1972): Correlation structure of skull dimensions in European Hedgehogs. Acta Theriol. **17**, 419–442.

Sneath, P. H.; Sokal, R. R. (1973): Numerical Taxonomy. San Franscisco: W. H. Freeman.

Wettstein, O. (1942): Die Säugetierwelt der Ägäis, nebst einer Revision des Rassenkreises von *Erinaceus europaeus*. Ann. Nat.-Hist. Mus. Wien **52**, 245–278.

Wettstein, O. (1966): Bemerkungen über einige Säuger des griechisch-kleinasiatischen Raumens. Sitzungsberichte österr. Acad. Wiss. mathem. naturwiss. Kl, **175**, 357–362.

Wilkinson, L. (1987): SYSTAT, The System for Statistics. Evanson, IL: Systat Inc.

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